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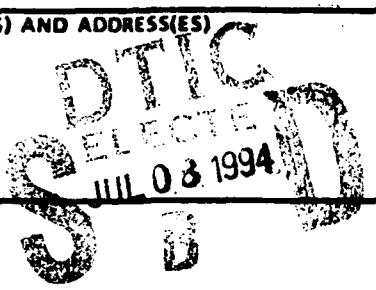

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Navigation Satellite Timing and Ranging (NAVSTAR) Global Positioning System (GPS) provides two positioning services: The Standard Positioning Service (SPS) and the Precise Positioning Service (PPS). PPS receivers have the capability of removing the effects of Selective Availability (SA) and operating in an Anti-spoofing (A-S) environment. PPS receivers can obtain absolute, stand-alone, real-time positions accurate to approximately 10 meters, horizontally. In the past, PPS users wore green suits, and SPS users were everyone else. Agencies within the Department of Defense (DOD) can obtain PPS receivers; agencies outside of DOD are writing Memorandums of Agreement (MOA) with DOD to also obtain PPS receivers. This paper will discuss the capabilities of PPS GPS and how a U.S. Army Corps of Engineers (USACE) Division or District can obtain them.

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PPS GPS: WHAT IS IT? AND HOW DO I GET IT?

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BIOGRAPHICAL SKETCH

Mr. Thomas Cox is a research scientist at the U.S. Army Topographic Engineer Center (TEC). He received a B.S. degree in Mathematics from James Madison University. Mr. Cox is responsible for the development of navigation hardware and software for military systems. His current research includes the development of low cost man portable navigation systems.

ABSTRACT

Navigation Satellite Timing and Ranging (NAVSTAR) Global Positioning System (GPS) provides two positioning services: The Standard Positioning Service (SPS) and the Precise Positioning Service (PPS). PPS receivers have the capability of removing the effects of Selective Availability (SA) and operating in an Anti-spoofing (A-S) environment. PPS receivers can obtain absolute, stand-alone, real-time positions accurate to approximately 10 meters, horizontally. In the past, PPS users wore green suits, and SPS users were everyone else. Agencies within the Department of Defense (DOD) can obtain PPS receivers; agencies outside of DOD are writing Memorandums of Agreement (MOA) with DOD to also obtain PPS receivers. This paper will discuss the capabilities of PPS GPS and how a U.S. Army Corps of Engineers (USACE) Division or District can obtain them.

INTRODUCTION

The NAVSTAR GPS was introduced to the U.S. Army Corps of Engineers in the mid to late 80's as a tool to meet survey requirements. The Corps has used GPS to do control and hydrographic surveys, dam deformation monitoring and photo control surveys to name a few applications. These GPS applications yield very accurate positions by using differential techniques and, for the most part, using carrier phase measurements which require expensive GPS receivers and associated equipment. Geographic Information Systems data collection, flood level delineation and other projects which require 10-15 meters positional accuracy can use low cost Precise Positioning Service (PPS) receivers. These receivers use the encrypted P code (Y code) to determine absolute positions in real time. Absolute positioning refers to the use of one GPS receiver to determine a 3D position in an earth reference system, such as WGS84. These receivers are produced to meet DOD's military requirements. The USACE, as a Department of Army component, can procure PPS receivers. PPS receivers can provide a low cost positioning solution where precise position accuracy is not needed.

GPS POSITIONING SERVICE

The NAVSTAR GPS is a timing and ranging system developed by the DOD to provide all-weather and 24 hour positioning for the United States military. The GPS signal is made of two parts, the carrier frequencies and the modulated codes. The carrier frequencies are the L1 with a frequency of 1575.42 MHZ and the L2 with a frequency of 1227.60 MHZ. The Course/Acquisition (C/A) and Precise (P) pseudo-random codes and the navigation message are modulated on the carrier frequencies by a technique called Binary Biphase Modulation (BBM). BBM creates, from a specific algorithm, the random like succession of 0 and 1 values which make up the pseudo-random codes. These values are called chips rather than bits to indicate they do not carry data. The C/A code has a chip frequency of 1.023 Mbps with a wavelength of 300 meters and a repeat period of 1 millisecond. The C/A code is transmitted only on the L1 carrier frequency. The P code has a chip frequency of 10.23 Mbps with a wavelength of 30 meters and repeat period of approximately 39 weeks. Each satellite (up to 32) is assigned a one week segment of the P code. The P code is transmitted on the L1 and L2 carrier frequencies. The navigation message has a message data rate of 50 bps with a repeat period of 30 seconds. The navigation message contains the satellite ephemerides, GPS time, clock behavior, and system status message. The navigation message is transmitted on the L1 and L2 carrier frequencies.

GPS absolute positioning uses ranges measured simultaneously between four satellites and the GPS receiver antenna to compute position. Ranges, called pseudo-ranges because the measurements include errors, are measured by matching a replica code generated within the receiver with the received code from the satellite using autocorrelation techniques. The code matching represents the transit time, which is the length of time it takes the satellite transmitted code to reach the receiver, which includes GPS errors. The pseudo-range is computed by multiplying the speed of light by the transit time. The errors which affect the code signal are satellite orbit, satellite clock, receiver clock, and atmospheric propagation errors.

The Standard Positioning Service is a positioning and timing service which is broadcast in the clear and available to anyone worldwide. The C/A and navigation message are the two codes which make up the SPS. The SPS has been intentionally degraded by a technique called Selective Availability (SA). SA is implemented by degrading the stability of the satellites on board atomic clocks (introducing clock errors) and by degrading the navigation message transmitted by the satellite. SA is on and will remain on. The degradation of the SPS signal can be set at any level. Under normal conditions, the U.S. Government guarantees to limit the errors, so that a computed position will be in error by no more than 100 meters horizontal (2 drms, 95 percent probability), 140 meters vertical (95 percent

probability), and timing accuracy will be within 340 nanoseconds (95 percent probability).

The Precise Positioning Service is a highly accurate positioning, velocity, and timing service used by DOD and its allies worldwide and is unavailable to unauthorized users. PPS data is transmitted on the L1 and L2 frequencies. PPS uses a technique known as Anti-Spoofing to verify that the signal being received is a true PPS signal and not an imitated one (spoofing). In order to implement A-S, the P code is encrypted to a new code called the Y code. The expected positional accuracy for the PPS is 16 meters 3D (SEP), 10 meters 2D (CEP), and 10 meters vertical (PE).

PPS RECEIVERS

A PPS receiver receives the PPS signal and removes the errors introduced by SA and reads the Y code to implement A-S. SA errors are removed from a PPS receiver by a device called the Precise Positioning Service-Security Module. The Auxiliary Output Chip (AOC) handles the A-S by decrypting the Y code back to the P code. Each channel in the receiver has an AOC. These security devices require a cryptographic key in order for the receiver to use the PPS. A keyed PPS receiver is not classified, but should be handled as any other accountable property. When the PPS receiver does not have valid cryptographic keys, it operates as a SPS receiver.

The Precise Lightweight GPS Receiver (PLGR), AN/PSN-11, is the authorized US military hand-held PPS GPS receiver. The PLGR is manufactured by Rockwell International Corporation. The PLGR is available, with all accessories, for a cost of $1500.

PPS receivers are available through several GPS manufacturers. Some provide the full PPS-SM and AOC capability, while others provide only PPS-SM. PPS receivers, having only the PPS-SM, should be used only in non-spoofing environments. These receivers can be purchased for cost of $3500-5000.

PURCHASE OF PPS RECEIVER

USACE, being a component of the DOD, has authorization to purchase PPS receivers.

PLGR can be purchased from the Program Manager GPS, the DOD organization that administers the PLGR contract. A memorandum to PM-GPS requesting the purchase of PLGR is required. It must contain the name of the organization, the number of PLGR receivers being purchased, and a requirement for PLGR (Figure 1). In addition to the memorandum, a current PLGR order worksheet (Figure 2) must also be prepared. These documents need to be sent to: Readiness Management Division, PM-GPS, ATTN: SFAE-CM-GPS-RMD (Mr. Ned McCracken), Bldg 915, Ft. Monmouth, NJ 07703. Once the request has been approved, PM-GPS will notify the

purchaser and will provide instructions to Military Interdepartmental Purchase Request the purchase funds.

PPS receivers, from commercial GPS manufacturers, are purchased through standard government contracting procedures. However, a memorandum to the NAVSTAR GPS Joint Program Office (JPO) for approval to release the security devices to the GPS manufacturer is required. Specific instructions on obtaining the necessary security devices for commercial PPS receivers are contained in Rules for Obtaining NAVSTAR Global Positioning System Security Devices. Requests for approval by JPO should be sent to: Headquarters Space and Missile Systems Center, ATTN: CZU, Los Angeles Air Force Base, PO Box 92960, Los Angeles, CA 90009-2960.

ACQUISITION OF THE CRYPTOGRAPHIC KEYS

All PPS receivers require cryptographic keys to use PPS. All cryptographic (i.e. Communication Security (COMSEC)) keys for US users are produced by the National Security Agency (NSA). The keys are provided in hard copy form as punched and printed paper tape segments.

There are two types of operational keys, the Key Encryption Key (KEK) and the Key Production Key (KPK). Both key types are classified CONFIDENTIAL and marked CRYPTO. The KEK is a Group Unique Variable (GUV) key. The KEK is the primary key to be issued to PPS GPS users. The KEK is valid for one year. The KPK is a Crypto Variable Weekly (CVW) key. The KPK is issued by exception for those applications where the use of the KEK is inappropriate. The KPK is valid for one week. USACE organizations will only use the KEK (GUV).

The keys come in three different formats, the ASCII 8-level punched, Hexadecimal printed, and Decimal printed. The ASCII 8-level punched format is used with a COMSEC fill device, the KOI-18 general purpose tape reader and the KYK-13 electronic transfer device. The Hexadecimal printed format is used with the GPS data loader, equivalent NSA approved key loader, or manual entry via keyboard. Decimal printed format is for manual entry only. The COMSEC fill devices, KOI-18 and KYK-13, are only available to organizations with a Table of Distribution and Allowances (TDA). This is a schedule of equipment a government agency is authorized to have. Some USACE organizations may have a TDA, but most do not. Those that do and have fill devices or will obtain fill devices can use any of the three key formats, assuming a PPS receiver with manual entry capability. Those that do not will have to use one of the two printed formats for manual entry of the keys. If an organization does not have a TDA, be aware, some PPS receivers do not have the provision to load key manually from the keyboard. The short key titles for the three KEK (GUV) formats are: AKAT A110n - ASCII 8-level punched, AKAK A110n - Hexadecimal printed, and AKAK F110n - Decimal printed.

The keys are ordered by a letter or a message, through a COMSEC account custodian, identifying the short key title and the number of keys required (Figure 3). The request should be sent to: CECOM Communications Security Logistic Activity, CDRUSACCSLA, ATTN: SELCL-KPD-KEY (Mrs Susan Krausman), Ft. Huachucha, AZ 85613-7090. Again, all requests must go through a COMSEC account custodian. All USACE Divisions and some Districts have valid COMSEC accounts and custodians.

CONCLUSION

The PPS receiver is an inexpensive solution to low accuracy positioning requirements. If the need to obtain a PPS receiver or the cryptographic keys should arise, the information provided should make the acquisition process a simple matter.

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U.S. Army Topographic Engineer Center
7701 Telegraph Road, Bldg 2592
Alexandria, VA 22315-3864

CETEC-TD-GS 5 Jun 9X

MEMORANDUM FOR Program Manager, GPS, ATTN SFAE-CM-GPS-RMD (Ned McCracken), Bldg 915, Murphy Drive, Fort Monmouth, NJ 07703

SUBJECT: Purchase of Precision Lightweight GPS Receivers (PLGRs) for Position and Navigation Research and Demonstration.

1. The subject purchase was discussed in a telephone conversion between Mr. Ned McCracken, Office of Program Manager GPS and Mr. Richard Marth of this office on 3 Jun 9X. The purchase of five (5) PLGRs is requested by 1 AUG 9X.

2. We are investigating low cost navigation capabilities for mounted and dismounted troops. Our investigations to date indicate an integration of a GPS receiver and a dead-reckoning navigator has the potential of providing the Army with a low cost navigator. We have integrated a commercial GPS receiver and a dead reckoning navigator and the integration is working quite well. As part of the overall effort to keep the cost of the navigator down, our next step is to use fielded military equipment. The use of PLGR will help us bring the GPS receiver portion of cost to zero since PLGR will be issued to the units where the navigator will be used. The requested PLGRs will help us in our integration effort and also help us meet the low cost goal.

3. We are working with the U.S. Army Materiel Command FAST representative in Europe, Dr. Christensen, to demonstrate the navigator on three vehicles during an exercise in Sep 9X. We plan to use SINCGARS to report the vehicle positions back to a command and control center. The requested PLGRs will be used one per vehicle, one at the command and control center and one for a spare.

5. The point of contact for this purchase is Mr. Richard Marth, DSN: XXX-XXXX or COMM: XXX-XXX-XXXX.

FOR THE DIRECTOR

PETER J. CERVARICH
Chief, Surveying Division

Figure 1

NSN	Nomenclature	Unit Cost	Quantity	Total Cost
REQUIRED ITEMS:				
5825-01-374-6643	PLGR Receiver	$1272.00		
n/a	Memory Battery	3.00		
n/a	Essential Performance Requirement	57.00		
5895-01-375-7828	Personnel Case	21.00		
n/a	Manual	3.00		
n/a	Field Check List	1.00		
	Total for Required Items	$1357.00		
OPTIONAL ITEMS:				
5895-01-374-7757	Helmet Antenna Set	$97.00		
5975-01-375-1302	Installation Mount	9.00		
6150-01-375-8661	External Power Cable (DC)	22.00		
5985-01-375-4660	Remote Antenna w/Mount (magnetic mount)	85.00		
6150-01-375-8662	Remote Antenna Cable	32.00		
6150-01-375-8663	PLGR to PLGR Cable	12.00		
6150-01-375-8664	PLGR to PC Cable (RS-232)	27 00		
6150-01-375-8665	PLGR to HAVEQUICK Cable	6.00		
6130-01-376-2168	Power Adaptor (110V A/C)	13.00		
6150-01-375-8666	PLGR to SINCGARS Cable	32.00		
		TOTAL		

Activity Ordering:	MIPR Number:
Shipping Address:	

Clear the request to purchase PLGR's and establish delivery schedule with:
Readiness Mgt Div, PM-GPS (SFAE-CM-GPS-RMD), Ft. Monmouth, NJ 07703
DSN: 992-6304 COMMERCIAL: 908-532-6304 FAX: 992-6304

Send cleared order and funding document to:
GPS Joint Program Office (Army), SMD/CZA (ATTN: Edgar D.W. Beverly)
2435 Vela Way, Suite 1613, LA AFB, CA 90245-5500
DSN: 833-6288 COMMERCIAL: 310-363-6288 FAX: 833-0643

Orders received by the 5th of a month will be placed on contract that month.

FIGURE 2: PLGR ORDER WORKSHEET (Good Until 30 Sep 94)

U.S. Army Topographic Engineer Center
7701 Telegraph Road, Bldg 2592
Alexandria, VA 22315-3864

CETEC-TD-GS 22 Jun 9X

MEMORANDUM THRU TEC Security Office

FOR CECOM Communications Security Logistic Activity, CDRUSACCSLA, ATTN: SELCL-KPD-KEY (Mrs Susan Krausman), Ft Huachucha, AZ 85613-7090

SUBJECT: Request for GPS Cryptographic Key

1. The U.S. Army Topographic Engineer Center (TEC) has recently purchased three AN/PSN-11 Precise Lightweight GPS Receivers. One receiver will be used to support the Survey Division in data acquisition procedures and data reduction techniques. The other two receivers will be used to support the TEC Water Detection Response Team which operates in remote areas of the world. These activities, require the GPS receiver to be capable of removing the effects of SA and defeat attempts to spoof while in the field.

2. Request that TEC be supplied with two (2) each operational keys, AKAK A110X, Hexidecimal printed format. The TEC COMSEC account number is XXXXXXX.

3. The point of contact for this request is Bryn Fosburgh, DSN: XXX-XXXX or COMM: XXX-XXX-XXXX.

FOR THE DIRECTOR

PETER J. CERVARICH
Chief, Surveying Division

Figure 3